the Liverworts and Characeæ, with an appendix to the species of Mosses and Hepaticæ, and a copious index. The vascular cryptogams are described by Stenzel, and include twenty-one genera, fifty-three species, and ten sub-species. A history of the discovery of Silesian Pteridophyta is prefixed, and an interesting account of their distribution. Thus the species found on serpentine, limestone, and other rocks, are noted, as well as the hypsometrical distribution. Four regions of elevation are distinguished: 1, from 55 metres to 150 m.; 2, from 150 m. to 500 m.; 3, from 500 m. to 1,100 m.; and 4, from 1,100 m. to 1,500 m. The arrangement of some of the species and sub-species is not quite in accordance with our English ideas. Thus *Woodsia hyperborea*, Koch, is separated into two sub-species: 1, *arvonica*, With.; and 2, *rufidula*, Sw.; equal to *hyperborea* R., Br. and *ilvensis* R., Br. respectively. *Cystopteris montana* of British botanists is *C. sudetica*, Al. Braun and Milde. Then *A. dilatatum*, *spinulosum*, and *cristatum*, are all placed as sub-species of *Aspidium spinulosum*, Sw., and *A. aculeatum lobatum*, and *angulare* are made sub-species of *A. aculeatum*, Döll.

The Mosses and Liverworts are described by Limpricht, and occupy the greater part of the volume, there being 106 genera and 464 species of Mosses, and 39 genera and 132 species of Hepaticæ. A few additional species are added in the Appendix, bringing up the Mosses to 492 species and the Liverworts to 155. The same arrangement is here followed as to history and distribution as in the case of the vascular cryptogams. The descriptions seem excellent, and the information given very full and complete, the characters of the orders and families being given in great detail.

The Characeæ have been described by Prof. Alexander Braun. Probably this was one of the last important works from his prolific pen. All must deplore his recent loss. His vast knowledge, the importance of his contributions to botany, and his genial kindly manner, the readiness he always showed in assisting his students, are well known. To know him was to love him, and we esteem it a high privilege to have been one of his students. The Characeæ are not very numerous, three genera and fourteen species being enumerated; but in the hands of Prof. Braun it becomes a most valuable memoir on the whole group, while the species likely to be found in Silesia are all pointed out. The synonymy must be very confused, as Braun notices that *Chara flexilis*, Waller, includes three or four species of *Nitella*, three of *Tolypella*, and one *Chara*, *C. gracilis* of Sprengel is a still greater monster, as it includes five species of *Nitella*, one *Lychnothamnus*, and three species of *Chara*.

W. R. McNab

The Countries of the World, being a Popular Description of the Various Continents, Islands, Rivers, Seas, and Peoples of the Globe. By Robert Brown, M.A., Ph.D., &c. Vol. I. (London: Cassell, Petter, and Galpin. No date.)

This is certainly an attractive book; the wealth of illustrations renders it so. While we recognise some of the illustrations as having done service elsewhere, many of tehm are new, well-executed, and afford a good idea of the scenery, products, and people of the regions they are meant to illustrate. This volume treats of the Arctic regions and North America, contains a great amount of miscellaneous information, and is written in a rambling easy-going style. It is essentially a popular work, but might have been made valuable even to the geographical student had some of the pictures been dispensed with and a number of regional maps substituted similar to those which are so important a feature in Reclus' "Géographie Universelle," with which masterly and exhaustive work, however, it would be unfair to compare it. We have no doubt Dr. Brown's work will afford pleasure and prove instructive to many readers.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

The Radiometer and its Lessons

Having been prevented from attending the recent meeting of the British Association by the necessity of devoting my entire vacation to mental and bodily renovation after the sad family losses I had sustained, I have only become aware within the last few days that my article in the April number of the *Nineteenth Century*, entitled "The Radiometer and its Lessons," had been there spoken of by Prof. G. Carey Foster, in his address as President of Section A, as showing an "unmistakable tendency, *either intentionally or unintentionally*, to depreciate Mr. Crookes's merits, and to make it appear that he had put a wrong interpretation upon his own results," which statement is said by your reporter to have "elicited great applause."

Of Mr. Crookes's own reply in the July number of the same periodical, entitled "More Lessons from the Radiometer," I took no notice; partly because my mind was at the time fully occupied by sad cares and urgent duties, and partly because I thought that his assertions (1) that he had not theorised on the subject at all, (2) that he had not attributed the rotation of the radiometer to the direct impetus of light, and (3) that he had never claimed the discovery of a new force or a new mode of force, were so well known in the scientific world to be inconsistent with fact, that I need not trouble myself to refute them.

Prof. Carey Foster, however, speaking with authority as President of the Physical section of the British Association, has given it as his judicial opinion that what I have written on this subject shows an unmistakable tendency to depreciate Mr. Crookes's merits, and to misrepresent his opinions; and he has further "unmistakably" suggested (as it appears to me) that this *may* have been done with deliberate intention, instead of being done in good faith under the influence of an unintentional bias. As it is impossible for me to allow such an imputation from such a quarter to pass unnoticed, I might fairly challenge Prof. Carey Foster to justify language which I must presume him to have used with all due consideration of its obvious meaning, and of *his* and *my* relative positions. But as he explicitly disavows the more serious part of this imputation, I have now only to ask to be allowed to show, in the columns of the journal which has not only recorded the accusation, but has pointedly directed attention to it,—*first*, that I have not, *even unintentionally*, "depreciated Mr. Crookes's merits" as the inventor of the Radiometer; and *secondly*, that Mr. Crookes really did in the first instance put that "wrong interpretation upon his own results" which I attributed to him. Had Prof. Carey Foster complied with the request I privately made him, that he should specify the passages which (in his opinion) justify his charge, I should have been able to reply to it much more briefly. But by declining thus to particularise, he obliges me to traverse the whole ground covered by his general accusation.

That I was not influenced, when writing on the Radiometer, by any *animus* arising from my personal antagonism to Mr. Crookes on another subject, will appear, I think, from the following extracts from the two lectures which I delivered at the London Institution (by special request) on Mesmerism, Spiritualism, &c., before Christmas, and which were published in *Fraser's Magazine* at the commencement of the present year:—

"The recent history of Mr. Crookes's most admirable invention, the Radiometer, is pregnant with lessons on this point. When this was first exhibited to the admiring gaze of the large body of scientific men assembled at the *soirée* of the Royal Society, there was probably no one who was not ready to believe with its inventor that the driving-round of its vanes was effected by the direct mechanical aid of that mode of Radiant Force which we call Light; and the eminent Physicists in whose judgment the greatest confidence was placed, seemed to have no doubt that this mechanical agency was something outside Optics properly so called, and was, in fact, if not a new Force in nature, a new *modus operandi* of a force previously known under another form. There was here, then, a perfect readiness to admit a novelty which seemed so unmistakably demonstrated, though transcending all previous experience. But after some little time the question was raised, whether the effect was not really due to an intermediate action of that *mode* of Radiant Force which we call *heat*, upon the attenuated vapour of which it was impossible entirely to get rid; and the result of a most careful and elaborate experimental inquiry, in which nature has been put to the question in every conceivable mode, has been to make it (I believe) almost if not quite certain, that the first view was incorrect, and that Heat is the real moving power, acting under peculiar conditions, but in no new mode."—*Lectures on Mesmerism and Spiritualism*, p. 8.

"I hold the warning given by the history of this inquiry, in regard to the duty of the scientific man to exhaust every possible mode of accounting for new and strange phenomena, before attributing it to any previously unknown agency, to be one of the most valuable lessons afforded by Mr. Crookes's discoveries.

"Now I maintain that it requires exactly the same kind of specially trained ability to elicit the truth in regard to the phenomena we are now considering, as has been exerted in the researches made by the instrumentality of the Spectroscope and the Radiometer. And I cannot but believe that if Mr. Crookes had been prepared by a special training in the bodily and mental constitution, abnormal as well as normal, of the Human instruments of the Spiritualistic inquiries, and had devoted to them the ability, skill, perseverance, and freedom from prepossession, which he has shown in his Physical investigations, he would have arrived at conclusions more akin to those of the great body of scientific men whom I believe to share my own convictions on this subject."—*Op. cit.*, p. 70.

No one, I think, can fail to see that in speaking of Mr. Crookes's "most admirable invention," and in giving him the fullest credit for the "ability, skill, perseverance, and freedom from prepossession," with which he had carried on his investigations in regard to it, I eulogised him as warmly as if I had never come into collision with him. It must also be apparent to any reader of these lectures, that I did not impute to him any blame for having originally fallen into an error shared at the time by the "eminent Physicists in whose judgment the greatest confidence was placed;" and that my reason for bringing forwards the subject was to enforce the lesson, that "no new principle of action has any claim to scientific acceptance, save after an exhaustive inquiry as to the extent to which the phenomena can be accounted for, either certainly or probably, by agencies already known."

Circumstances to which I shall presently advert having made me feel it desirable that this "lesson" should be yet more fully and emphatically set forth, I applied myself to a careful reperusal of Mr. Crookes's papers in the *Proceedings* of the Royal Society, with the most earnest desire to present a true history of the whole inquiry; and I availed myself of the opportunity kindly afforded me by the editor of the *Nineteenth Century*, to place before the public what I believed to be a fair statement of the case, with the lessons it conveyed.

Commencing with a description of the phenomena presented by the Radiometer when it was first exhibited by Mr. Crookes at the *soirée* of the Royal Society, I thus continued:—

"It is scarcely surprising, then, that a general impression should at once have prevailed that a capital discovery had been made—that of the *direct mechanical action of light;* which, though not indicating the existence of a new force in nature, showed that the most universally diffused of all forces, next to gravitation, has a *mode of action* which was previously not merely unknown, but altogether unsuspected. And this impression was not confined to those who had only a general acquaintance with Physical Optics; for it was shared by the greatest masters of that department of science, who had followed the course of the experimental researches on which Mr. Crookes had been for some time engaged, and of which this discovery was the culmination."—*Nineteenth Century*, April, 1877, p. 243.

I then went on to give, from Mr. Crookes's papers, a history of the investigations which had led him up to the Radiometer; and showed (p. 249) that at that stage of the inquiry, the argument for the *directness of radiant repulsion*, deducible from what was then supposed to be a fact—the increase of the rapidity of the rotation in proportion to the perfection of the vacuum—"seemed alike valid and cogent."

I next sketched the history of the opposite view originally propounded by Prof. Osborne Reynolds, supported by Dr. Schuster's experiment, and finally established by Mr. Crookes's own later researches, which have culminated in the doctrine of "heat reaction" now generally accepted. In reference to Mr. Crookes's own part in these subsequent inquiries, I say later on (p. 254), that "no sooner was adequate ground shown for calling in question his interpretation of the phenomena, and a *vera causa* found in an agency already known, than Mr. Crookes evinced the spirit of the true philosopher in varying his experiments in every conceivable mode, so as to test the validity of his original interpretation." And again in the next page I speak of his "carrying out this beautiful inquiry in a manner and spirit worthy of all admiration."—What higher praise *could* be given to a scientific investigator?

Having brought the history to its conclusion, I thus proceed:—

"Before adverting to the lessons which this remarkable history seems to me to convey, I would point out that this change of interpretation of the facts discovered by Mr. Crookes, does not in the least diminish either the interest of the facts themselves or the merit of his discovery. Nor is the value of his Radiometer in any degree lowered by the demonstration that it does not (as Mr. Crookes at first supposed) afford an absolute mechanical measure of radiant energy under any of its aspects. What (according to present views) it really does measure, is the amount of 'heat reaction' producible in gaseous atmospheres of different kinds and of different degrees of attenuation. And such a precise method of measurement appears more likely than any other mode of investigation, to furnish a test of that kinetic theory of gases, the recent development of which by Prof. Clerk-Maxwell is regarded by competent judges as constituting (if it should receive such verification) the most important advance ever made in molecular physics. Most deservedly, therefore, did Mr. Crookes receive from the Royal Society the award of one of its chief distinctions." (*Loc. cit.*, p. 251.)

To this I may add that I personally congratulated Mr. Crookes most cordially on that occasion, and expressed to him the deep interest with which I had followed his researches throughout. And though I had next to show that Mr. Crookes has another side to his mind, which makes Mr. Crookes the "spiritualist" almost a different person from Mr. Crookes the "physicist," I carefully guarded what I had to say on this point in the following words:—

"I would not be thought for one moment to disparage Mr. Crookes's merits as the inventor of the Radiometer, by now bringing into contrast with the admirable series of scientific investigations which led up to that invention, what I cannot but regard as his thoroughly unscientific course in relation to another doctrine of which he has put himself prominently forward as the champion."

I cannot but surmise that Prof. Carey Foster must have read my paper rather carelessly, and have applied to Mr. Crookes, the inventor of the Radiometer, the depreciatory remarks I felt called upon to make in regard to Mr. Crookes, the supporter of a system, a large proportion of which even Mr. D. D. Home has recently denounced as "a seething mass of folly and imposture."[1] If Prof. Carey Foster knew as much as I do of the mischief which *this* Mr. Crookes has done, especially in the United States, on the one hand to his own reputation and to that of British science,[2] and on the other to public morality, by the facility with which he has lent himself to the support of frauds as wicked as those by which fortune-tellers delude ignorant and credulous servant-girls, he would not wonder that I should feel called upon to show that the high scientific ability of Mr. Crookes, the Physicist, neither prevents him from believing in his own day-dreams, nor renders him a match for the cunning of the clever female cheats who play upon his Spiritualistic "prepossessions."

I now pass to the second part of my defence; and shall show that for "making it appear that Mr. Crookes had put a wrong interpretation upon his own results," I can adduce adequate justification from his own published statements.

Of the "repulsion accompanying radiation" shown in his early experiments by the swinging-round of the pith bar, Mr. Crookes said, in 1874 (*Phil. Mag.*, vol. xlviii., p. 94), "*My own impression is that it is directly due to the impact of the waves*

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[1] See his "Lights and Shadows of Spiritualism," containing an unsparing exposure of its "delusions," its "absurdities," and its "trickeries."

[2] On the strength of a private letter from Mr. Crookes, which has been published (in *fac simile*) in the American newspapers, a certain Mrs. or Miss Eva Fay announced her "spiritualistic" performances as "endorsed by Prof. Crookes and other Fellows of the Royal Society." The particulars of the complete public exposure of this woman's disgraceful frauds, showing that Mr. Crookes's *scientific tests* are no more worthy of trust than the late Prof. Hare's *experimental demonstration of the immortality of the soul*, will appear in the forthcoming number of *Fraser's Magazine*.

upon the surface of the moving mass, and not secondarily through the intervention of air-currents, electricity, or evaporation and condensation."

In a paper subsequently communicated to the Royal Society (*Proceedings*, March 12, 1875), Mr. Crookes characterised the explanation of the "repulsion from radiation" offered by Prof. Osborne Reynolds, as one which "*it is impossible to conceive*," the phenomenon taking place in a *chemical* vacuum. At the same time he stated that he was unprepared to offer any other explanation, and that "he should avoid giving any theory on the subject until a sufficient number of facts have been accumulated."

After bringing out the Radiometer, however, he reverted (as it seemed to me) to his previous "impression;" the whole phraseology of his papers of January 5 and February 5, 1876, appearing at the time, not only to myself, but to every one of the eminent scientific friends with whom I conversed on the subject, to indicate that he *then* considered the rotation as *directly due to the impact of the waves upon the surface of the moving mass.* Nor have I ever imputed it to him as a matter of blame that he took this view of it; on the other hand I have stated over and over again that this seemed the general impression of the distinguished Physicists to whom we "outsiders" looked for guidance in the matter. Anyone who remembers what took place at the Meeting of the Royal Society at which Mr. Crookes's paper was read, will, I feel sure, bear out this statement.

I shall now specify more explicitly the grounds on which I attributed to Mr. Crookes, no longer as an "impression," but as a definite "interpretation" of his facts, that the rotation of the Radiometer is due to the *direct impact of the waves*, and chiefly (I never said exclusively) to those of the *luminous* waves; and further attributed to him a claim to the discovery of a "new force" or "new mode of force."

This *key-note* seems to me to be most distinctly struck in the following passage:—After pointing out that "there is no real difference between Heat and Light, all we can take account of [I presume he means physically, not physiologically] being difference of wave-length," he thus continues: "Take, for instance, a ray of definite refrangibility in the red. Falling on a Thermometer it shows the action of *Heat;* on a Thermopile it produces an *electric current;*[1] to the Eye it appears as *light and colour;* on a Photographic plate it causes *chemical action;* and on the suspended pith *it causes motion.*"

Now (1) this motion being elsewhere spoken of as due to *the impetus given by a ray of light,* (2) a set of experiments being made to determine *the mechanical values of the different colours of the spectrum,* (3) an observation being recorded on *the weight of sunlight* (without the least intimation that he was "speaking figuratively," as Mr. Crookes says that he did to his audience at the Royal Institution), (4) the term *Light-mill*[2] being used by himself as a synonym for "Radiometer," and (5) no hint whatever being given of the dependence of the result (as argued by Prof. Osborne Reynolds) on a "heat-reaction" through the residual vapour, I still hold myself fully justified in attributing to Mr. Crookes the doctrine of *the direct mechanical action of light;* and I call on Prof. Carey Foster to prove—not that Mr. Crookes himself did not hold that doctrine—but (which is a very different thing) that I am not justified by Mr. Crookes's own language in attributing it to him.

That Mr. Crookes considered such action a "new force" or a "new mode of force," plainly appears from my previous citation; in which he ranks Motion as a mode of Radiant action *additional* to Light, Heat, and Actinism, differing as much from either of them as they differ from each other. If it does *not* mean this, what does it mean?

So, if Mr. Crookes has *not* changed his mind as to the interpretation of his facts, I ask (1) why he now repudiates as inappropriate the term *Light-mill* adopted (if not originally given) by himself? and (2) why does he now admit that dependence of the movements upon the presence of residual gas, which he originally affirmed to be *impossible to conceive?*

I have carefully confined myself to the *main issues* of this question. Prof. G. Carey Foster will doubtless be able to pick out *points of detail* in my article, as to which fault may be found by a severe critic. But I venture to think that I have said enough to prove that what I said on the subject was written under the honest conviction that I had adequate ground for my statements; and that I shall at any rate be absolved from the imputation of having ill-naturedly referred to the history of the Radiometer for the purpose of putting Mr. Crookes in the wrong; the "lesson" with which I concluded the article being as follows:—

"The lesson which this curious contrast [the 'duality' of Mr. Crookes's mental constitution, which I speak of as having plenty of parallels in past times, to say nothing of the present] seems to me most strongly to enforce, is that of the importance of training and disciplining the *whole* mind during the period of its development, of cultivating scientific habits of thought (by which I mean nothing more than strict reasoning based on exact observation) in regard to *every* subject, and of not allowing ourselves to become 'possessed' by any ideas or class of ideas, that the common sense of educated mankind pronounces to be irrational. I would not for a moment uphold that test as an infallible one; but it ought to be sufficiently regarded, to make us question the conclusions which depend solely upon our own or others' subjectivity, and to withhold us from affirming the existence of new agencies in Nature, until she has been questioned in every conceivable way, and every other possibility has been exhausted." (*Op. cit.*, p. 256.)

October 10 WILLIAM B. CARPENTER

I HEAR from Dr. Carpenter that he is sending to you, for publication in the next number of NATURE, a statement intended as a refutation of an opinion which I ventured to express, in my address to the Mathematical and Physical Section of the British Association at Plymouth, respecting an article on the "Radiometer," contributed by him to the *Nineteenth Century* for April. As Dr. Carpenter appears to have interpreted that expression of opinion in a sense different from that which it was intended to convey, I shall be much obliged if you will afford me space in your next issue for a few words of explanation.

The words which I used in referring to his article were these: "An eminent and accomplished scientific man had published, within the last few months, an account of the discovery of the radiometer, the unmistakable tendency of which was, either intentionally or unintentionally, to depreciate Mr. Crookes's merits, and to make it appear that he had put a wrong interpretation upon his own results." The word *depreciate*, which occurs here, is, I am aware, susceptible of various shades of meaning, and perhaps it would have been better if I had guarded myself against the possibility of misconception that lurks in it. What I meant was that Dr. Carpenter's account of Mr. Crookes's researches was likely to make his readers form a lower estimate of their scientific value than, in my opinion, they deserved; but whether or not it was *intended* to have this effect I did not undertake to say. I did not mean, and had not the smallest idea of suggesting, that Dr. Carpenter had been guilty of intentional and conscious unfairness towards Mr. Crookes. I should have thought it entirely unnecessary to disavow this latter interpretation of my words, and indeed should have considered it an insult to Dr. Carpenter's reputation to suppose that anyone would understand them in this sense, had he not himself (in a recent correspondence with me) endeavoured to fix this meaning on them in spite of my repeated assurances that it was not intended.

I do not wish to say anything on this occasion in support of the opinion which I have admitted that I did intend to express, but I shall ask you to allow me to do so in a future number of NATURE. G. CAREY FOSTER

University College, London, October 14

Mr. Wallace and Reichenbach's Odyle

As Mr. Wallace has attempted (presumably with Mr. Crookes's editorial concurrence) to rehabilitate, in the July number of the *Quarterly Journal of Science*, the Odyle-doctrine of Baron Reichenbach, I think it well to state that I yesterday availed myself of an opportunity of personally asking my friend

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[1] Having never heard of any physical philosopher from Seebeck to Sir William Thomson, who looked at the *electric current* generated in the Thermopile as anything else than an effect of the *heating* (whether by *conduction* or by *radiation*) of the two metals of which it was composed, I was greatly surprised at finding it ranked by Mr. Crookes as one of the *immediate* modes of Radiant action; and I called attention in my "Radiometer" paper to what I supposed to be his mistake on this point. It may be that in my ignorance of the newest developments of thermo-electric theory (my knowledge of it not being later than 1872, "Everett's translation of Deschanel," p. 652), I have here unintentionally "depreciated Mr. Crookes's merits;" and I shall be quite ready to recant and apologise for my mistake, if Prof. G. C. Foster will show that it is Dr. Carpenter, not Mr. Crookes, who is here in the wrong.

[2] It is impossible not to see, in the use of this term, a suggestion that the vanes are driven round by the direct mechanical impetus of Light upon them, in the same way as the sails of a Wind-mill are driven round by the direct impetus of the Wind.